DEPENDENCE OF QUANTUM SIZE OSCILLATIONS PERIOD ON COMPOSITION OF $Bi_{1-x}Sb_x$ POLYCRYSTALLINE THIN FILMS

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Crystals and thin films of $Bi_{1-x}Sb_x$ solid solutions are well known as promising thermoelectric (TE) materials for refrigerating devices. The development of nanotechnologies has stimulated studies of $Bi_{1-x}Sb_x$ thin-film structures. Due to their extremely low effective electron masses and a high charge carrier mobility, these materials are very convenient for observing quantum size effects. Recently, interest in studying the transport properties of $Bi_{1-x}Sb_x$ thin films has grown due to the observation of the topological-insulator properties in $Bi_{1-x}Sb_x$ solid solutions.

Previously, in the laboratory of semiconductor physics and thermoelectricity of NTU "KhPI" a number of experimental results were obtained on the TE properties of thin $Bi_{1-x}Sb_x$ films [1-3]. All films with thicknesses d = 10-400 nm were prepared by thermal evaporation in vacuum from a single source ($Bi_{1-x}Sb_x$ polycrystals) with subsequent deposition onto (111) mica surface and had the orientation in the direction of the trigonal axis. It was established that room-temperature d-dependences of electrical conductivity, the Hall coefficient, Seebeck coefficient, and TE power factor for thin films grown from crystals with x=0, 0.02, 0.045, and 0.09 had oscillatory character. The theoretically calculated value of Δd, using the model of an infinitely deep quantum well, was in good agreement with the experimental one.

The purpose of the present work is to analyze the previously obtained experimental data and identify the dependence of the oscillation period Δd on composition (x=0, 0.02, 0.045, and 0.09) and the nature of oscillation manifestation depending on d.

Based on the experimental results, we have built the dependences of oscillation period on composition (x) and established that Δd increases with increasing Sb content almost linearly. With x increasing as 0.00 (Bi)→0.02→0.045→0.09, the oscillation period Δd increases as 25 → 45 → 75→105 nm. The surprising fact is that quite clear oscillations for all compositions are observed not only at low temperatures but also at room temperature (300 K). Although several propositions have been made, a definitive explanation for this fact has yet to be found.

References:

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